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# 1. Product Definition and Information

## 1.1. Description of Company/Organization

Firestable Insulation Company is a leading manufacturer of fire-resistant spray polyurethane foam systems and operates in two manufacturing facilities:

- In Houston, Texas, USA:
  size of site: 125k ft2
  Number of employees: 23

- In Essex, Connecticut, USA:
  Size of site: 25k ft2
  Number of employees: 13

## 1.2. Product Description

**Product Identification**

This declaration covers water blown closed-cell spray polyurethane foam insulation manufactured under Firestable brand by FIC.

**Product Specification**

Spray polyurethane foam (SPF) is made on the jobsite by combining polymeric methylene-diphenyl diisocyanate (pMDI/MDI or A-side) with an equal volume of a polyol blend (B-side). Sides A and B react and expand at the point of application in the building envelope to form polyurethane foam. The formed-in-place SPF provides both thermal insulation and air sealing to the building.

The Firestable 2.0 provides a water-resistant insulation, water-vapor control, air-sealing and delivers an additional structural performance to the building envelope.

SPF products are commonly used in residential, commercial, institutional, and certain industrial applications. Typical properties of the various SPF products are shown on Table 1.

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***Table 1: Typical WB ccSPF properties***

| PROPERTY | VALUE |
|---|---|
| Density [lb / ft3] | 2.0 to 2.8 |
| Thermal resistivity [R / in] | 5 |
| Air permeable material | ✓ |
| Integral vapor retarder | ✓ |
| Water resistant | ✓ |
| Cavity or exterior insulation | ✓ |
| Continuous insulation | ✓ |
| Soil Gas Barrier | ✓ |
| Rainscreen | ✓ |
| Fungi Resistant | ✓ |
| Air Quality – Greenguard(in Process) | |
| Structural Improvement | ✓ |

## Flow Diagram

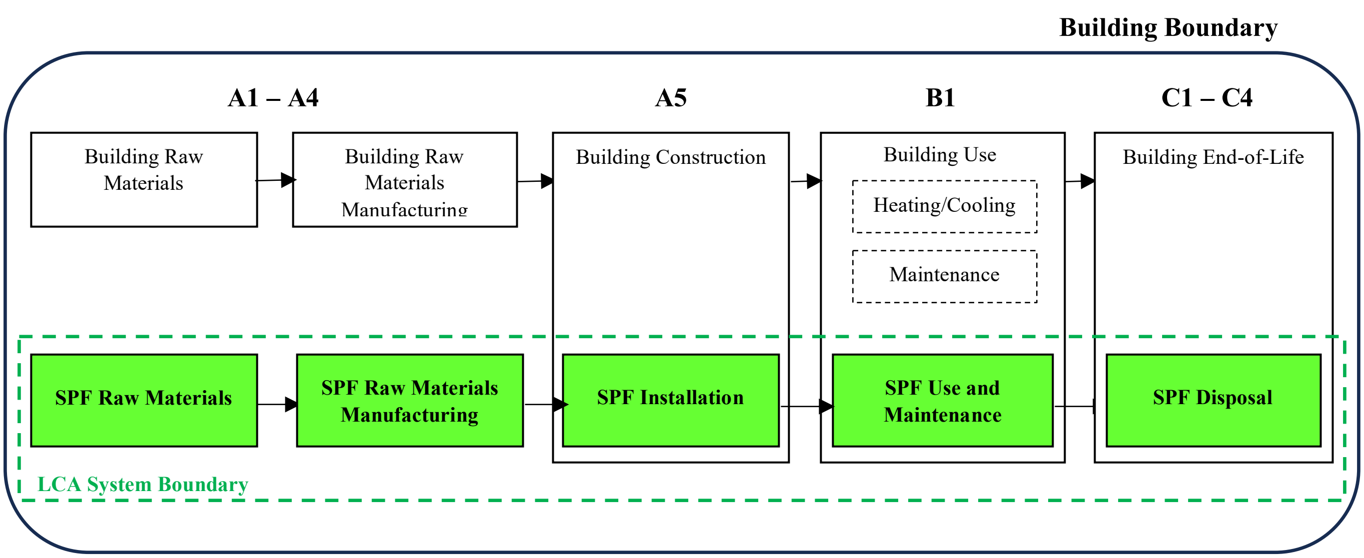


**Figure 1: Product flow diagram**

## 1.3. Application

Closed-cell product applied to the interior or exterior side of the building envelope as an insulation, water-sealing, vapor-sealing, structural integrity and air-sealing material.

## 1.4. Declaration of Methodological Framework

# ENVIRONMENT

This EPD is declared under a cradle-to-grave boundary. As such, it includes all life cycle stages including any off-gassing emissions from the blowing agent associated with use of the product. Per the product category rules (UL Environment, 2018), the assessment was conducted using a building service life of 75 years. Material and energy inputs were allocated on a mass basis. Recycled content and disposal at end-of-life follow the cut-of allocation approach. No inputs or outputs were deliberately excluded from this EPD.

### 1.5. Technical Requirements

All SPF products must meet numerous performance requirements to comply with building codes. The detail of these requirements is described in specific tests listed in consensus standards for material performance and code compliance. A summary of these consensus standards is provided in Table 2 below:

***Table 2: Summary of technical Standards for SPF in Construction***

| Standard Type | ROOFING | CLOSED CELL | OPEN CELL |
|---|---|---|---|
| ASTM | ASTM C1029<br>Type III and IV or<br>ASTM D7425 | ASTM C1029<br>Type I and II | ASTM WK30150 |
| CAN/ULC | | S705.1 | S712.1 |
| ICC Building Code Compliance | | ICC-ES AC-377<br>ICC-1100-20XX<br>NFPA 275 | |

ATM Standards

- C1029-15 Standard Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation UL Canada Standards
- S705.1-15 Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density International Code Council Standards.
- ICC-ES AC-377 Acceptance Criteria for Spray-Applied Foam Plastic Insulation
- ICC-1100-20xx Standard for Spray-Applied Polyurethane Foam Plastic Insulation Canadian Construction Materials Centre
- CCMC Evaluation Reports and Listings
- NFPA 275 Certification

Typical material performance requirements per ICC-1100 are provided in Table 2 below.

***Table 3: Summary of Typical Material Performance Requirements for SPF in Construction***

| PERFORMANCE REQUIREMENT | STANDARD | VALUE |
|---|---|---|
| Thermal Resistance (R-value) | ASTM C518, C177 or C1363 | As reported<br>(typ R4.4-5.0/inch |
| Surface Burning Characteristics | ASTM E84 or UL723 | Flame spread index ≤ 75<br>Smoke developed ≤ 450 |

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| | | |
|---|---|---|
| Core Density | ASTM D1622 | As reported (typ 2.0-2.8 pcf) |
| Closed-Cell Content | ASTM D2856 or ASTM D6226 | ~ 90% |
| Tensile Strength | ASTM D1623 | 15 psi min (100kPa) |
| Compressive Strength | ASTM D1623 | 15 pi min (100 kPa) |
| Dimensional Stability | ASTM D2126 | 15% max change |
| Water Vapor Permeance | ASTM E96 (dry cup) | As reported (typ 1 US perm @ 2" thk / 60ng @ 51 mm) |
| Air Permeance | ASTM D E283 or D2178 | As reported (typ imperm @ 2.5" thk / 38mm) |
| Water Absorption | ASTM D2842 | < 5% max |

## 1.6. Properties of Declared Product as delivered

The A-side and B-side required to produce SPF are delivered to the job site in separate containers. On the job site, these chemicals are mixed in equal volume proportions to create SPF.

## 1.7. Material Composition

The A-side of SPF is made from a blend of polymeric methylene diphenyl diisocyanate (MDI). The B-side is a mixture of polyester and or polyether polyols, flame retardants, blowing agents, catalysts, and other additives that, when mixed with A-side, creates foam that can be applied for insulation.

Since one half of the formulation by volume is MDI (A-side), the table focuses on the other multi-component half (B-side). Firestable Insulation Company product composition is proprietary, so an approximative composition of chemical components is shown.

While some of the ingredients may be classified as hazardous, per the Resource Conservation and Recovery Act (RCRA), Subtitle 3, the product as installed and ultimately disposed of is not classified as a hazardous substance, as hazardous ingredients are rendered chemically inert after installation.

***Table 4: Firestable 2.0 formulation***

| CHEMICAL | | COMPOSITION |
|---|---|---|
| Polyols | Polyether | < 25% |
| | Mannich | < 20% |
| | Proprietary | < 25% |
| Fire Retardant | TCPP | < 20% |
| Blowing Agent | Reactive (H2O | < 3% |
| Catalyst | Amine | < 4% |
| | Metal | < 2% |

# ENVIRONMENT

| | | |
|---|---|---|
| Surfactant | Silicone | < 2% |
| Dispersing additive | Unsatured polycarboxylic acid polymer and polysiloxane copolymer | < 0.5% |

## 1.8. Manufacturing

During the B-side production processus, materials are blended in tanks and packaged. The B-side formulation is made by two facilities, one in Texas and one in Connecticut. The Texas facility utilizes technology to minimize dust contamination and the release of gaseous material during material transfer and processing. Waste materials are typically reintegrated into the formulation without additional collection, transport, or processing.

## 1.9. Packaging

The high-pressure SPF chemicals are packaged in steel drums. Finished packaged products are loaded onto pallets, where additional shipping materials, such us strapping, cardboard, and plastic wrap, are used. In this study, it is assumed that the empty chemical containers are properly cleaned and taken to a recycler.

## 1.10. Transportation

Final products are distributed via container truck, either directly to customers, or first to warehouse, prior to being sent to customers. Table 5 details distribution assumptions for finished SPF products.

## 1.11. Product Installation

Firestable SPF series are installed by trained/certified professional applicators by on-site mixing of the A-side and B-side chemicals.

Installation includes insulation of the walls, floors, and ceilings of entire buildings. These chemicals are delivered to the jobsite in unpressurized containers (usually 55-gallon drums) and heated to approximately 110-130 °F (43-54 °C) and pressurized to about 1000 psi by specialized equipment. The chemicals are transferred by a heated hose and aerosolized by a spray gun and combined by impingement mixing at the point of application. Personal protective equipment such us goggles, protective suits, and respirator cartridges is required to protect applicators from chemical exposure during installation. Also needed are disposable materials such us masking tape and drop cloths. The schematic in Figure 2 shows the typical equipment components used to produce high-pressure SPF foam, including unpressurized A-side and B-side liquid drums with transfer pumps, which are connected to the proportioner system for heating and pressurizing the chemicals, and then through a heated hose connected to a spray gun for application.

Disposal of Packaging materials is modeled in accordance to the assumptions outlined in Part A of the PCR (UL Environment, 2018). All ancillary installation materials are assumed to be sent to landfill.

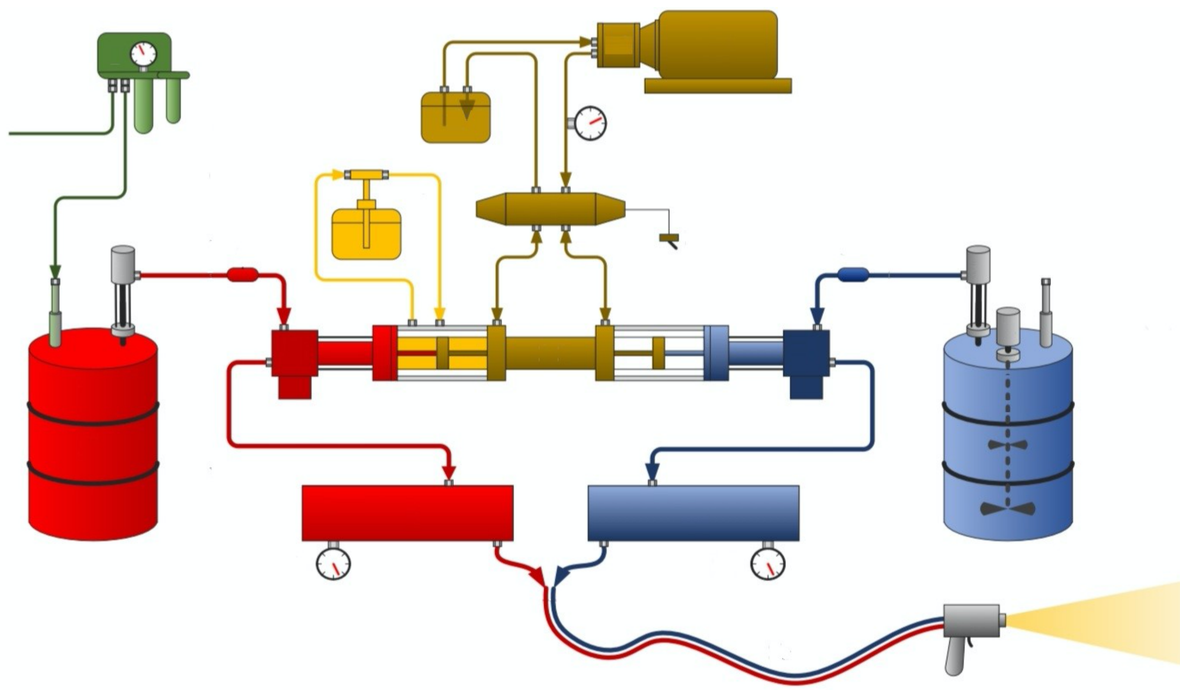

**Figure 2: Schematic of a High-Pressure SPF system**

### 1.12. Use

As this study only looks at the life cycle of spray foam insulation, and not the building, the use phase only contains the emissions of any chemicals off gassed from the foam.

### 1.13. Reference Service Life and Estimated Building Service Life

The reference service life (RSL) for SPF is the life of the building or 75 years. Additional information is provided in Table 7.

### 1.14. Disposal

When the building is decommissioned, it is assumed that only manual labor is involved to remove the foam. Wastes are estimated to be transported < 5 miles to the disposal site. The spray foam is assumed to be landfilled at end-of-life, as is typical for construction and demolition waste in the US. This study assumes the spray foam is inert in the landfill (Kjeldsen & Jensen, 2001).

## 2. Life Cycle Assessment Background Information

### 2.1. Functional or Declared Unit

The product function is providing insulation to buildings. Accordingly, the functional unit for the study is 1 m2 of installed insulation material with a thickness that gives an average thermal resistance of Rsi=1$m^2 \cdot K/W$ (in imperial units, Rsi=1 is equivalent to R = 5.68 $h \cdot ft^2 \cdot °F/Btu$) with a building service life of 75 years (packaging included).

### 2.2. System Boundary

The study uses a cradle-to-grave system boundary. As such, it includes upstream processing and production of materials and energy resources needed for the production of SPF, transport of materials (all chemical inputs for production and packaging) to SPF formulation sites, formulation of SPF components, transport of the components to the installation site, installation of insulation, removal and transport of insulation to disposal site, and end-of-life-disposal. Building energy savings from the use of insulation are excluded from this analysis.

### 2.3. Estimates an Assumptions

The material and energy inputs and outputs were modeled according to data provided by the representative site, while the electricity grid and natural gas mix were chosen based on the locations of the production facility.

## 2.4. Cut-off-Criteria

The cut-off criteria for including or excluding materials, energy and emissions data of the study are as follows:

- **Mass –** If a flow is less than 1% of the cumulative mass of the model it may be excluded, providing its environmental relevance is not a concern.
- **Energy –** If a flow is less than 1% of the cumulative energy of the model it may be excluded, providing its environmental relevance is not a concern.
- **Environmental relevance –** If a flow meets the above criteria for exclusion yet is thought to potentially have a significant environmental impact, it was included. Material flows which leave the system (emissions) and whose environmental impact is greater than 1% of the total of an impact category that has been considered in the assessment must be covered. This judgment was made based on experience and documented as necessary.

Packaging of incoming raw materials (e.g. pallets, totes, super-sacks) are excluded as they represent less than 1% of the product mass and are not environmentally relevant. Capital goods and infrastructure required to produce and install SPF (e.g. batch mixers, spraying equipment) are presumed to produce millions of units over the course of their life, so impact of a single functional unit attributed to this equipment is negligible; therefore, capital good and infrastructure were excluded from this study. No known flows are deliberately excluded from this EPD.

## 2.5. Data Sources

The LCA model was created using the GaBi software system for life cycle engineering, developed by Sphera Solutions, Inc. The GaBi 2022.2 LCI database provides the LCA model as well as the background data used.

**Temporal coverage. {In Process 2024}**

The data are intended to represent spray polyurethane foam production during the 2024 calendar year.

**Geographical coverage**

The background LCA represents FIC’s product produced in the United States. Primary data are representative of this country. Regionally specific datasets were used to represent each manufacturing location’s energy consumption. Proxy datasets were used as needed for raw material inputs to address lack of data for a specific material or for a specific geographical region. These proxy datasets were chosen for their technological representativeness of the actual materials.

**Technological coverage**

Data on material composition were collected directly from FIC. Manufacturing data were provided by FIC for the Firestable Series product. Waste, emissions, and energy use are calculated from reported annual production during the reference year.

### 2.6. Period under Review {in process2024}

Primary data collected represent production during the 2024 calendar year. This analysis is intended to represent production in 2024.

### 2.7. Allocation

The cut-off allocation approach is adopted in the case of any post-consumer and post-industrial recycled content, which is assumed to enter the system burden-free. Only environmental impacts from the point of recovery and forward (e.g., inbound transports, grinding, processing, etc,) are considered.

## 3. Life Cycle Assessment Scenarios

***Table 5: Transport to the building site (A4)***

| NAME | UNIT | VALUE |
|---|---|---|
| Fuel type | | Diesel |
| Fuel economy, outbound transport (medium truck) | l/100km | 44.0 |
| Fuel economy, jobsite transport (light truck) | l/100km | 19.6 |
| Outbound distance | km | Varies |
| Capacity utilization (including empty, mass based) | % | 69 |
| Weight of products transported (if gross density not reported) | kg | 1.25-1.35 |

***Table 6: Installation into the building (A5)***

| NAME | UNIT | VALUE |
|---|---|---|
| Ancillary materials | kg | 0.011-0.013 |
| Net freshwater consumption specified by water source and fate (amount evaporated, amount disposed to sewer) | $m^3$ | - |
| Other resources | kg | - |
| Electricity consumption | kWh | 0.04-0.045 |
| Diesel for construction equipment | MJ | 2.65-2.85 |
| Product loss per functional unit | kg | 0.028-0.034 |

| | | |
|---|---|---|
| Output materials resulting from on-site waste processing (for recycling) | kg | - |
| Biogenic carbon contained | kg CO2 | - |
| Direct emissions to ambient air, soil, and water | kg | - |
| VOC content | µg/m$^3$ | - |

***Table 7: Reference Service Life***

| NAME | UNIT | VALUE |
|---|---|---|
| RSL | Years | 75 |
| Declared product properties (at the gate) and finishes, etc. | m$^2$ | 1 |
| | $R_{SI}$ | 1 |

***Table 8: End of life (C1-C4)***

| NAME | UNIT | VALUE |
|---|---|---|
| Collected as mixed construction waste | kg | 1 |
| Landfill | kg | 1 |

***Table 9: Reuse, recovery and/or recycling potentials (D), relevant scenario information***

| NAME | UNIT | VALUE |
|---|---|---|
| Net energy benefit from steam recovery from waste treatment declared as exported energy in D | MJ | Est. 0.003 |
| Net energy benefit from electricity recovery from waste treatment declared as exported energy in D | MJ | Est. 0.007 |

## 4. Life Cycle Assessment Results

As this cradle-to-grave declaration, all modules are declared, as seen in Table 10. However modules B2 to B7, C1 and C3 do not contribute impact and are therefore declared as zero.

***Table 10: Description of the system boundary modules***

| | PRODUCT STAGE | | | CONSTRUCTION PROCESS STAGE | | USE STAGE | | | | | | | END OF LIFE STAGE | | | | BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A1** | **A2** | **A3** | **A4** | **A5** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** | **C1** | **C2** | **C3** | **C4** | **D** |
| | Raw material supply | Transport | Manufacturing | Transport from gate to site | Assembly/install | Use | Maintenance | Repair | Replacement | Refurbishment | Building operational Energy Use During Product | Building Operational Water Use During Product | Deconstruction | Transport | Waste processing | Disposal | Reuse, Recovery, Recycling Potential |
| **Cradle to Grave** | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

## 4. Life Cycle Impact Assessment Results {in Process 2024}

North American LCIA results are declared using TRACI 2.1 methodology. Note that the IPCC AR5 GWP (IPCC, 2021) results are also presented as they are more current than the TRACI 2.1 GWP results. The TRACI 2.1 methodology refers to an earlier version of the IPCC report.

***Table 11. Firestable 2.0 results***

| TRACI V2.1 | A1-A3 | A4 | A5 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|
| GWP 100 [kg CO2 eq] | | | | | | |
| GWP 100, IPCC AR6 [kg CO2 eq] | | | | | | |
| ODP [kg CFC-11 eq] | | | | | | |
| AP [kg $SO_2$ eq] | | | | | | |
| EP [kg N eq] | | | | | | |
| POCP [kg $O_3$ eq] | | | | | | |
| $ADP_{fossil}$ [MJ, LHV] | | | | | | |

***Table 12. Resource use results***

| PARAMETERS | A1-A3 | A4 | A5 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|
| $RPR_E$ [MJ, LHV] | | | | | | |
| $RPR_M$ [MJ, LHV] | | | | | | |
| $NRPR_E$ [MJ, LHV] | | | | | | |
| $NRPR_M$ [MJ, LHV] | | | | | | |
| SM [kg] | | | | | | |
| RSF [MJ, LHV] | | | | | | |
| NRSF [MJ, LHV] | | | | | | |
| RE [MJ, LHV] | | | | | | |
| FW [$m^3$) | | | | | | |

***Table 13. Waste categories and output flows***

| PARAMETERS | A1-A3 | A4 | A5 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|
| HWD [kg] | | | | | | |
| NHWD [kg] | | | | | | |
| HLRW [kg] | | | | | | |
| ILLRW [kg] | | | | | | |
| CRU [kg] | | | | | | |
| MR [kg} | | | | | | |
| MER [kg] | | | | | | |
| EE, Steam [MJ, LHV] | | | | | | |
| EE, Electricity [MJ, LHV] | | | | | | |

## 5. LCA Interpretation

For HFC containing products, installation (A2), use (B1) and disposal (C4) are the greatest contributors to the GWP category due to the emissions of HFCs over the course of its lifecycle. HFO and Water Blown formulations do not have pronounced GWP impacts across the life cycle due to the lower blowing agent GWP characterization factors.

In nearly all other impact categories, SPF environmental performance is driven primarily by raw materials (A1). Installation tends to be the second highest driver of impact due to the use of on-site diesel generators, as well as waste foam disposal.

Though some raw materials are transported thousands of miles, the inbound transportation module (A2) has a modest contribution to overall impact. Other transportation modules representing transport to site (A4) and transport to end-of-life (C2), have negligeable contribution to life cycle results.

## 6. Additional Environmental Information

### 6.1. Environment and Health During Manufacturing and Installation

Manufacturing of SPF formulations and upstream chemicals are performed in an industrial manufacturing facility. Like many manufacturing processes, hazardous chemicals and manufacturing procedures may be employed. These manufacturers follow all local, state, and federal regulations regarding safe use and disposal of all chemicals (US EPA), as well as safety requirements required of the generally manufacturing operation of equipment and processes (US and State OSHA) and safe transport of all materials (US DOT) Environment and Health During Installation.
Installation of SPF involves potential exposure to certain hazardous chemicals that requires risk mitigation through the use of personal protective equipment and on-site actions including ventilation and restricted access. Of greatest concern is the potential exposure to airborne and liquid isocyanates during and immediately after installation of SPF. Isocyanates are known chemical sensitizers and exposure can occur through contact with the skin, eyes and respiratory system.

**ENVIRONMENT**

Ventilation of the work zone, coupled with use of proper personal protective equipment is required during and immediately after SPF installation. Please visit www.spraypolyurethane.org.

## 6.2. Extraordinary Effects

**Fire**

Spray Polyurethane foam, like all foam plastics and many construction materials – including woods – is a combustible material and will emit toxic gases including carbon monoxide during a fire. When used in buildings and other construction applications, foam plastics may need to be protected with fire-resistant coverings or coatings when used in certain construction applications, as dictated by the building codes. All foam plastics materials and assemblies should meet the fire test requirements of the applicable building codes.

**Water**

Closed-cell SPF products meet the FEMA Class 5 requirements[1] for flood-damage resistant insulation materials for floors and walls.

**Mechanical Destruction**

Should the assembly the SPF is installed in, i.e. the wall or ceiling, have to be replaced then the SPF will have to be replaced as well.

## 6.3. Environmental Activities and Certifications **{Red is pending}**

Firestable Insulation Company has certified or tested its insulation products to various VOC standards to measure emissions of volatile or semi-volatile compounds. These standards include:

- 415.EPD for SPFA-EPD-20181029.pdf
- SPFA_EPD_Background_Report_10_29_2018.pdf
- UL Environment GREENGUARD® Certificstion – The GREENGUARD® Certification Program specifies strict certification criteria for VOC's and indoor air quality. This voluntary program helps consumers identify products that have low chemical emissions for improved indoor air quality.
- California Department of Health Services – Also known as Section 01350, this small-chamber emissions test standard is detailed under: Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers (CA/DHS/EHLB/Standard Method v1. 1-2010).

# ENVIRONMENT

- Canadian ULC – Required for SPF Insulation products, this standard provides a similar VOC emissions test protocol specifically for SPF: CAN/ULC S774-09 Standard Laboratory Guide for the Determination of Volatile Organic Compound Emissions from Polyurethane Foam.
- Currently, an ASTM workgroup is developing a small-chamber emissions test protocol for chemical compounds specific to SPF that include MDI, blowing agents, flame retardants and catalysts.

## 6.4. Low-GWP Blown Agents

This EPD is based on an LCA of SPF products that use Water as chemical blowing agent. Because of the low global warming potential factor of $CO_2$ the emissions account for a small percentage of the global warming potential life cycle results.

## 6.5. References

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